



**DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026**  
**Erosion Prevention and Sediment Control Handbook**

### **4.3.2 Channels and Swales**



Source: TDEC

#### **Definition and Purpose**

Channels and swales are either natural or constructed wet weather runoff conveyance measures that are shaped or graded to required dimensions per engineering design. When appropriately sized and stabilized (Section 4.2.6.1), channels and swales convey concentrated runoff from the construction site to a receiving channel, waterbody, or other EPSC measure without damage from erosion.

#### **Appropriate Applications**

Channels and swales are applicable to construction that produces concentrated runoff. Typical locations include roadside ditches, channels at property boundaries, channels created by diversion structures, or channels and swales designed as part of a permanent storm water conveyance system for the site.

#### **Limitations and Maintenance**

Channels and swales require inspections routinely and after heavy rains. Inspect the channel for signs of scour, erosion, and overtopping. These may indicate an under-designed conveyance structure. Additionally, inspect channel and swale outlet(s) for signs of erosion



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and sediment deposition. Many outlets need to discharge into outlet protection or an energy dissipator (Section 4.3.4) in order to prevent erosion. If the construction site sediment yield is particularly high, or sediment is regularly observed in the conveyance structure or the outlet, consider implementing additional EPSC measures upstream or in the conveyance structure. Check dams (Section 4.3.3) and sediment tubes or socks (Section 4.4.9) can be used within conveyance structures to enhance runoff velocity control and sediment trapping. Trapped sediment needs to be removed as needed to maintain the design hydraulic capacity.

#### **Planning and Design Considerations**

Construct and stabilize channels and swales early in the construction phase; before surfaces are graded or paved, and runoff rates are increased. However, ensure other EPSC measures are in place before disturbance, such that channels and swales do not convey sediment-laden water when used as a diversion. When possible, drainage channels and swales should follow natural contours and make use of existing drainage paths. It is common to place conveyance structures near development edges, along roadways, or at the rear of property lines. Avoid routing them across watershed divides or ridge lines as this can disrupt natural flow patterns and complicate site hydrology. To the greatest extent possible, preserve natural drainageways and incorporate them into the site design (NCDEQ, 2013).

Channels and swale are typically trapezoidal, parabolic, or V-shaped (Figure 4.3.2-A). To select the ideal shape, determine the peak flow rate in which the channel or swale must adequately convey based on CGP or local requirements (Eqn 9 or Eqn 10). Trapezoidal and parabolic channels are ideal for conveying larger flow rates, while V-shaped channels are better for low flows (VDEQ, 2024). Additionally, consider the available space and site specific constraints to determine which shaped cross-section may work best.

Hydraulic computations for each channel shape are governed by channel geometries (Table 2-A), the Continuity Equation (Eqn 7), and Manning's Equation (Eqns 6 and 8). However, tools can be used to reduce computation time, ensure accurate computations, and/or for less typical cross-sectional shapes (Fang, 2007; Mejia & Ponce; Perez et al. 2015) as specified in Section 2.1.2. For adequate hydraulic capacity, ensure the peak flow rate computed from Manning's Equation is greater than the peak flow rate computed from Eqn 9, Eqn 10, or an acceptable modeling software. If stabilization measures are required, be sure the channel or swale is over-excavated to account for the thickness of stabilization measures or that the geometries of the channel or swale account for such thicknesses when computing the hydraulic capacity. Additionally, ensure the proposed side slopes coincide with recommendations for the stabilization measure. Manning's n values can be found for most materials (natural, bioengineered, or structural) in Sections 3.2.1 and 4.2.6; however, if



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specific stabilization measures are used, it is best to obtain this value from manufacturer specifications.

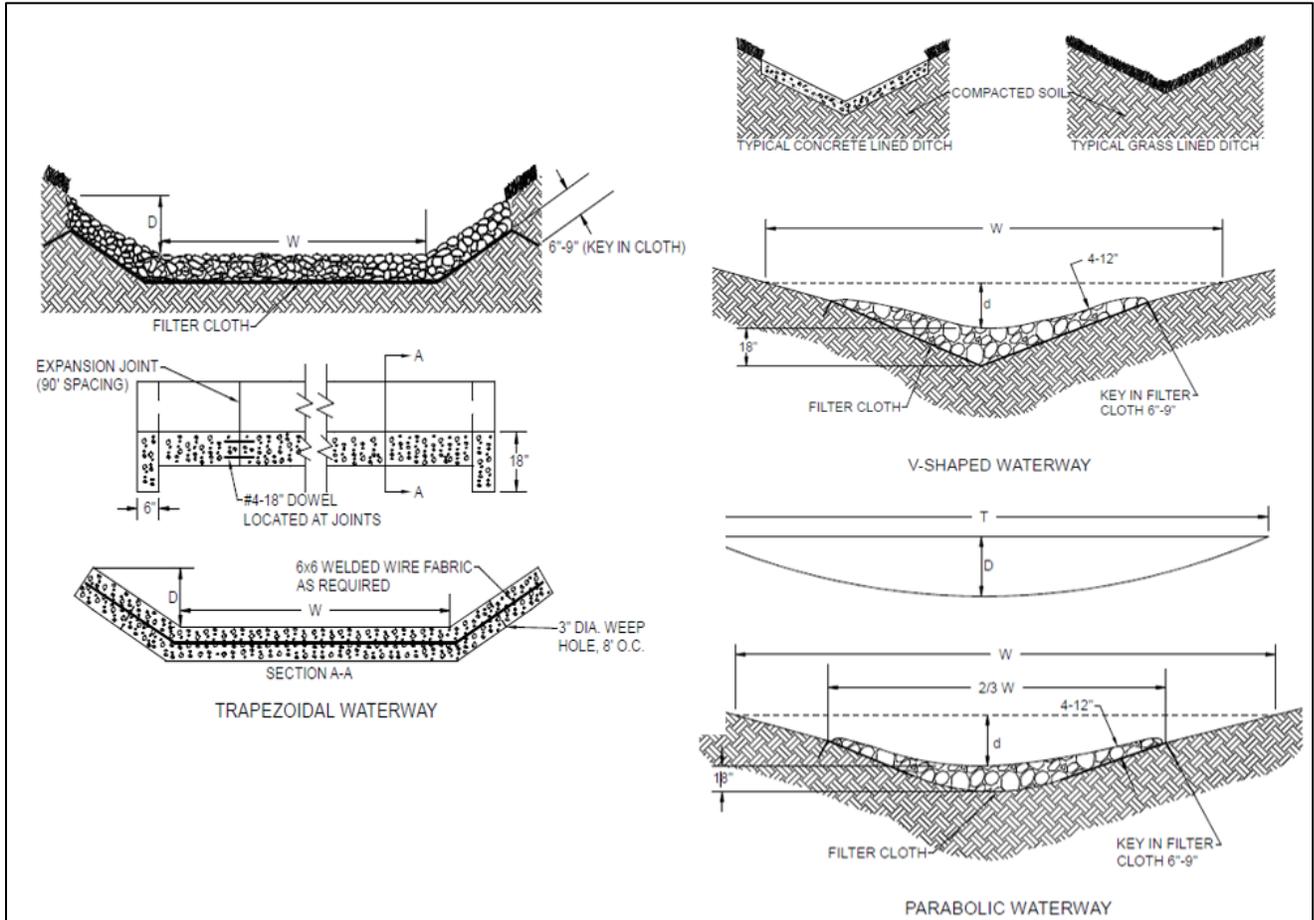


Figure 4.3.2-A: Channel and swale cross-sectional geometries. Adapted from VDEQ (2024).

Design dimensions of channels should be consistent with TDOT methodology. Helpful design charts to eliminate “guess and check” methods or substantially over-sizing the conveyance structure are presented in TDOT as well as Appendix C-ECM-09-a in VDEQ (2024), and Appendix 8.05 in NCDEQ (2013). Use Table 2-A or the previously mentioned tools to make note of the water surface elevation for the cross-section shape of choice during the design flow. Ensure this elevation is greater than the elevation of the receiving water during such a design event to prevent backflow and that this elevation is within the bounds of the channel or swale with sufficient freeboard. Lastly, use the wetted cross-section geometries to calculate the Froude Number, the ratio of internal forces to gravitational forces (Eqn 16):

$$F_r = \frac{V}{(g \times D)^{0.5}} \quad \text{(Eqn 16)}$$



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where  $V$  is the average cross-sectional design velocity in feet per second,  $g$  is the acceleration due to gravity in feet per square second, and  $D$  is the hydraulic depth in feet (which can be calculated from Table 2-A or the previously mentioned tools). When the Froude Number is greater than one, less than one, or equal to one, flow in the open channel conveyance is supercritical, subcritical, or critical, respectively. It is ideal to size the channel or swale such that supercritical flow is avoided. Consider altering cross-section geometries to achieve subcritical or critical flow, or retrofit a drop structure and hard armoring in the design.

Again, stabilization of channels and swales is likely necessary when design velocities exceed two feet per second (Section 4.2.6.1). In addition, channel outlets require stabilization. The discharge velocity for the design flow must be nonerosive for the existing receiving system conditions.

General hydraulic design guidance for channels and swales includes:

- Design must consider the construction phase and the permanent stormwater management conveyance (after construction is complete) phase. Factors used in the design should reflect such conditions;
- Where slopes over 10% and/or supercritical flow cannot be avoided, use FHWA's HEC 15 for a more detailed design using hard armoring and/or grade control structures;
- On steep slopes, shorten the effective slope length by installing "turn outs" that discharge runoff non-erosively over stable slopes; and
- At a minimum, the freeboard should be sufficient to prevent waves or fluctuations in the water surface from washing over the sides. In a permanent roadway channel, about half a foot of freeboard is generally adequate, and for transitional channels, zero freeboard may be acceptable. For steep gradient channels, use a freeboard height equal to the flow depth. This allows for large variations to occur in flow depth for steep channels caused by waves, splashing, and surging. Lining materials should extend to the freeboard elevation.

### **Example Application**

*Given:*

It is anticipated that a construction site will produce a concentrated flow at a design rate of 20 cubic feet per second.

*Determine:*

The geometries of a V-shaped channel to safely convey the design flow.

*Solution:*



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Generally, it would be most ideal to refer to the tables and appendices in TDOT, NCDEQ (2013), or VDEQ (2024) to eliminate guess work. However, for sake of demonstration, a run through of the calculations is provided.

Due to the ease of purchase, it has been determined the Class A-1 riprap will be used as a stabilization measure. Class A-1 riprap has a Manning’s n value of 0.33 and riprap cannot have a side slope steeper than 2H:1V (Section 4.2.6.4). Space constraints will likely permit side slopes as shallow as 4H:1V at a slope of 0.5%. For an examples using direct application of Manning’s Equation refer to Section 4.2.6.1. For this example, “The open channel flow calculator<sup>®</sup>” was used.

Using this tool, these maximum criteria can be input to the model along with the peak flow rate and it can calculate the hydraulic depth, D, as well as all other hydraulic geometries, as shown below.

These inputs yield a flow depth of 1.42 feet and a suitable design because the flow is subcritical. However, this may not optimally utilize the space on the construction site. Therefore, it may be ideal to input different channel geometries to obtain other suitable designs that utilize less space. With a V-shaped channel, only the side slopes can be adjusted, but for other shapes, the bottom width can also be adjusted. For this example, channel slopes of 3H:1V and 2H:1V were input to the tool. Slopes of 2H:1V produce a V-shaped channel with a flow depth of 1.88 feet that yields subcritical flow. Thus, this design was selected as it utilized the least amount of space. Ensure the channel is excavated to provide sufficient freeboard.

**References**

Fang, X. (2007). *The open channel flow calculator*.  
<https://www.eng.auburn.edu/~xzf0001/Handbook/Channels.html>



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Perez, M. A., Butler, C. G., & Fang, X. (2015). Compute critical and normal depths of arch and elliptical pipes. *Journal of Irrigation and Drainage Engineering*, 141(9), 06015001.

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